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ANCIENT SEA LIFE

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Acknowledgment

Cover: A photograph of what the floor of a Paleozoic sea must have looked like, courtesy of the Rochester Museum of Arts and Sciences, Rochester, New York.

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ANCIENT SEA LIFE

by Verne N. Rockcastle and Victor E. Schmidt

The stone in Bob's pocket wasn't just any old stone. It was a very special one. He found it one afternoon while hiking with his dog. He was throwing stones into a creek and had almost thrown this one when something about it caught his eye. There was a shell on one side of the stone.

The shell was an odd-looking one, something like a butterfly with its wings spread. Bob tried to loosen it with his fingernail but couldn't. It seemed to be a part of the rock itself. How did it get there? Was it valuable? Bob didn't know the answers to these questions, but he was sure that his dad would know. He knew everything—well, almost everything.

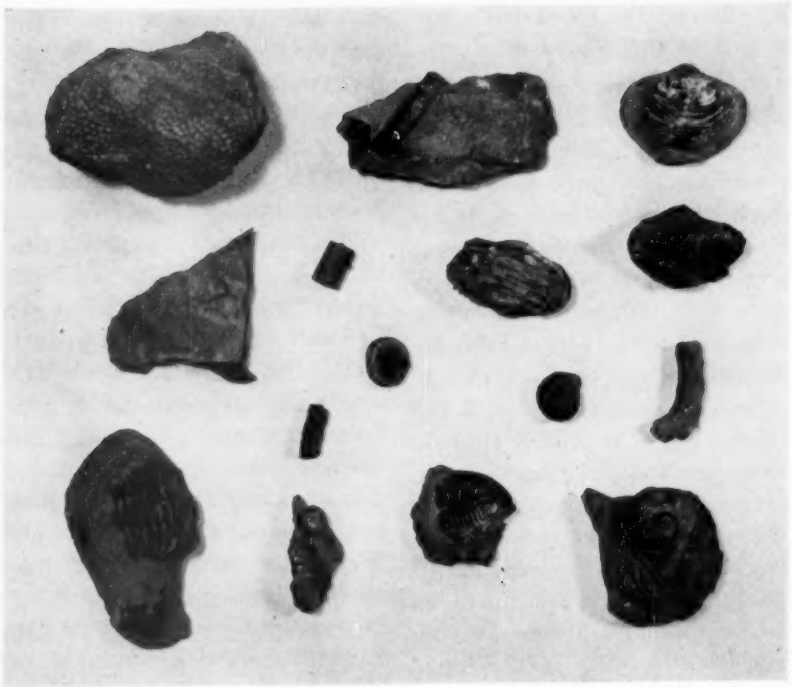
The next day at school Bob reached into his pocket and pulled out the stone, his face all smiles. "Look what I found yesterday," he exclaimed, "a rock with a shell in it. My father says it's a fossil."

"Let's see," interrupted Jane. Some of the other boys and girls crowded around. They were all eager to see the fossil that Bob had found.

"Just a minute, boys and girls," said Miss Hardy. "Bob, why don't you show your fossil to the class during our show-and-tell time? Then we can all see it while you tell us about it."

When Bob's turn came, he passed the stone around and said that he had found it near the creek on the Brady farm. His father had told him that it was the shell of an animal that lived a long, long time ago. John and Dick said that they had seen shells in stones, but none that were as big and clear as this one. Several other children said that they knew the place where Bob had found his fossil.

John's fossil



These are some of the fossils that the class found on their field trip

began to bombard Miss Hardy with questions such as these:

What are fossils, anyway?

How did they get into the rock?

How old are they?

How much are they worth?

Are they good for anything?

Can we find any dinosaur bones around here?

Are fossils being made now?

As you study fossils, you, too, may ask questions about them. This Leaflet may help you find the answers to some of them.

What Are Fossils?

Long ago people thought that fossils were freaks of nature. As scientists studied more and more about them, they became convinced that fossils are really the remains or traces of ancient plants and animals. Some are the remains of plants and animals that lived on land. Most fossils, however, like those that Bob's class found, are the remains of ancient sea life.

"Miss Hardy, could we go there sometime?" asked Mary. "I'd like to find some fossils."

"So would I."

"Me, too," said another. "Maybe we could even find some dinosaur bones." The whole class became enthusiastic about looking for fossils, and that is

How the Field Trip Began

"We could go Thursday afternoon if the weather is nice," said Miss Hardy. "You children would have to write notes to your parents asking for permission, and I'll speak to Mr. Hughes about letting us use a school bus."

The children wrote their notes, and together they composed a nice letter to Mr. Brady asking for permission to walk along his creek to hunt for fossils. He was pleased at their request, and even decided to take some time off from his chores to learn something about his own farm and the things that could be found there.

When all the plans for the field trip had been made, this is what the children agreed upon:

1. They would wear old clothes, and sneakers so they would not slip on the rocks and get hurt.
2. Each would bring some old newspaper to wrap his fossils separately, and a box in which to carry them.
3. John would try to borrow a hammer or two. Miss Hardy suggested that he ask a mason for a bricklayer's hammer because it has a sharp edge for chipping stone.
4. Each one would conduct himself like a good sportsman. He would be careful of fences and other property. Then Mr. Brady would be glad to have them back.

The big day arrived and the class went on their fossil-collecting trip. Bob showed his classmates where he had found his shell, and they began to search eagerly. One girl found a rock with many marks that looked like tiny wheels. Other children found shells of different shapes. One girl found one that looked like a snail shell, and another found one that reminded her of a small, crooked ice-cream cone. Even Mr. Brady found several fossils. He was having a wonderful time. Everybody found something. Bob was amazed at how many fossils the class was finding —many more than he thought could possibly be there. What he didn't realize was that thirty pairs of eyes were searching where only his had looked.

As the class found fossils, they

A hundred million years pass, and another hundred million. The mud and sand that were once a part of the sea bottom are now a part of the land, several hundred feet above the sea. The sediments that covered our shell have become layers of solid rock. The shell is now a fossil buried deep within them.

Air, rain and ice eat away at the rocks. Streams cut gullies. The gullies widen and deepen to become valleys. The decayed and crumbled rock is washed downhill. Much of it becomes silt and sand, carried to the sea where it may bury more shells. As the rock is eroded, the surface of the ground gets lower and closer to our fossil. Two hundred million years of weathering and erosion from water, air and ice finally reduce the rock to pieces. One of these pieces has the fossil shell in it. It is carried along by the creek on Mr. Brady's farm, and dropped in the creek bed. That is where Bob found it.

Bob's fossil is all that remains of a sea creature that lived more than 300 million years ago. Its soft parts disappeared soon after it died, but its hard part remained buried in rock for hundreds of millions of years. Bob found it only after erosion and weathering had exposed it. If Bob had not found it, in time it would have crumbled like the rock in which it was imbedded. In little bits it would have washed back to the sea.

Why Aren't There More Fossils?

From the story of the shell in Bob's rock, you learned that certain things have happened in order for you to find a fossil:

1. A sea creature died, leaving hard parts such as a shell or other kind of skeleton.
2. Before they were destroyed, the hard parts were buried by sea sediments.
3. These sediments were slowly raised above the sea, and formed rock which preserved the hard parts.
4. Slowly the rock layers were weathered and eroded to expose the fossil.
5. You found the fossil before it, too, was destroyed.

The mud that buries this shell may become a rock that contains a fossil millions of years from now

How Did the Fossils Get into the Rock?

Imagine an animal with a shell like those on the cover living on the bottom of a shallow sea a long time ago—perhaps as long as 300 or 400 million years ago. It has no name, for there is no one to give it a name. No humans have yet appeared on the earth, nor do whales or seals swim in the sea. No gulls fly over the water. There are only sea creatures—snails and clams and other shelled animals, starfishes and relatives of starfishes, corals, and soft-bodied creatures like jellyfish. Some crablike animals crawl around on the muddy bottom. A few fish swim among the seaweeds, but these are not like the tuna and cod and other fish that we know. Above the waves, the only sounds are the wind and the thunder; below the waves, a watery stillness. Weird sea animals move slowly over the bottom. A few plants sway with the movements of the water. Occasionally a sea animal moves swiftly, stirring up the silt and sand on the bottom. The sand settles quickly, but the silt slowly. Both settle softly, as silently as the snow falls on land.

Our sea-bottom creature lives its life, then dies as all living things must. Its soft body, if not eaten by scavengers, decays. In time all that is left of the animal is an empty shell lying in the mud and sand.

On the land nearby, air, rain and running water slowly wear away the surface. Rivers, muddy with millions of tiny bits of rock, make their way to the sea. There the mud, mixed with sand and stirred by the waves, slowly settles to the sea bottom. Little by little the shell is filled and covered with sediment. After a while it is no longer visible. It is completely buried in the sea bottom. Mud and sand continue to settle. Other creatures in other shells die and are buried, generation after generation, layer upon layer.

A thousand years pass, and another thousand, and another. The mud and sand pack tightly around the shell as more sediment settles to the sea bottom. The pressure increases steadily, but the shell is hard and resists being bent or crushed. More thousands of years pass, and hundreds of thousands, and then millions. Layer upon layer the sediments pile up, but now something new is happening. Slowly —so slowly that in your lifetime it would seem not to have moved at all—the sea bottom is lifted. As it is lifted, the shallow sea that covers it drains back into the ocean.

Fossils were formed in the shaded area, but glaciers carried many into unshaded areas

broken. Sometimes the fossils have come loose from the surrounding rock and lie exposed on the ground. Others are still firmly imbedded in the rock and can be loosened only by careful chipping. If you find a fossil imbedded in a piece of rock, do not be too eager to get it out. You may damage an otherwise excellent specimen. Leave enough of the surrounding rock so you do not damage the fossil.

Are Fossils Valuable?

Unlike buried treasure and some minerals, fossils are usually not valuable in themselves. You will seldom find one that is rare or perfect enough to sell to a museum, although your local museum may be glad to accept good specimens as gifts. Most of the fossils you find will be of greatest value to *you*. They will help you learn much about the geologic history of the earth and its inhabitants.

What Good Are Fossils?

Fossils furnish our best clues to the life, the geography, and the climate of the past. If it were not for them, we would have no way of knowing about many animals that roamed the earth, or that once crawled on the bottom of the ancient seas. In fact, we would not even know for sure that there were once seas in this region if it were not for the many fossils of sea animals that we find here.

They Show Us What Lived Long Ago

You can look at some fossils and see for yourself the shape of the ancient animals. Even if you collect only bits of one kind of fossil, you may still be able to tell what it looked like. Making sense out of fossil bits is a little like working a jig-saw puzzle. Sometimes you will lose pieces, but you can still recognize the picture and even use your imagination to fill in the missing details. The habits of ancient sea animals are not so easy to determine. So scientists study the structure and the habits of similar living animals to learn what the ancient ones must have been like. There are some things, however, that neither the study of fossils nor the study of similar living animals can tell us. For example, no

Usually all these things do not happen in the proper manner and in the right place to make a fossil. Many ancient creatures had no hard parts. Jellyfishes, for example, have rarely left traces in the rocks. Often even the hard parts were destroyed before being buried. Many of them were ground to bits by waves and currents. In some places, ancient sea sediments have never been raised out of water. There they lie, covered over with more recent sediment. Sometimes the sediments that were raised above the sea were washed back into the sea before they had a chance to harden.

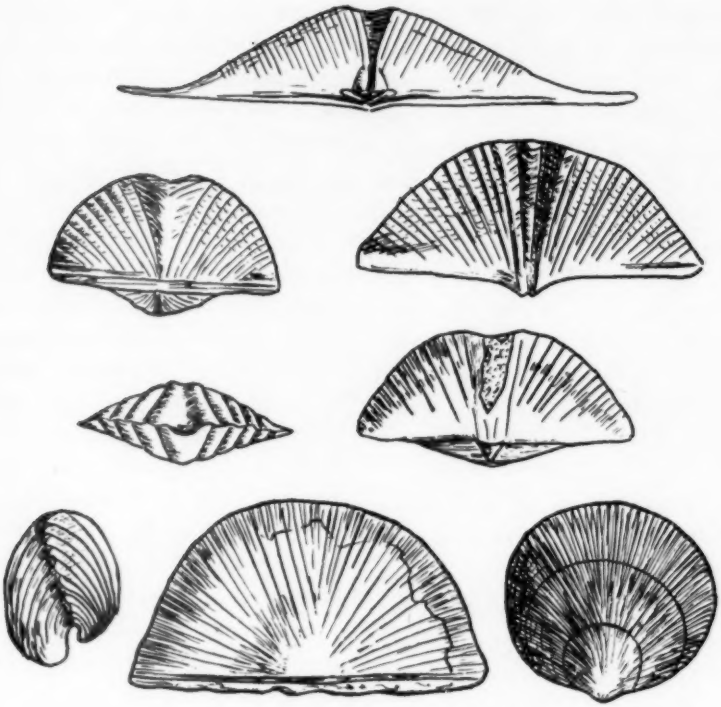
Even after being imbedded deep in layers of rock, many fossils were destroyed by intense heating or squeezing of the rocks that held them. Finally, of the millions of fossils that were buried in sediment and preserved for millions of years, most have been exposed by erosion, weathered to bits and washed away by the rain. Of the billions of plants and animals that once lived, relatively few have been preserved. You will find some of them on your fossil hunts. Thousands upon thousands still lie buried deep within the rocky ledges and hills about you. It will take many years of weathering and erosion to expose them, so there will be fossils for boys and girls to find for a long time to come.

When you find a fossil, remember that it indicates a unique series of events starting perhaps millions of years ago and ending with *you!* When you break a rock and find a fossil inside, you are the first person in all of history to see it!

Where Can You Find Fossils?

The shaded part of the map of New York State indicates areas where rocks that were formed from sea sediments lie at or near the surface. Many of these rock layers contain the shells and skeletons of ancient sea animals. If you live anywhere in this shaded area, you have an excellent chance of finding fossils in nearby rocks. No matter where you live in the State, however, you still have a good chance of finding fossils. The great ice sheets that once covered this region carried many pieces of fossil-bearing rock for long distances. When the ice melted, the rocks were dropped —some of them near your home.

To hunt for fossils, look at the rock layers and broken pieces of rock in cliffs and quarries, and along road cuts, stone walls, and stream banks. Weathered and crumbling pieces of rock often show the fossils in them better than rock which has been freshly



Some fossil brachiopods from the rocks of New York State

Brachiopods have a soft body. In most of them a fleshy stalk that extends through an opening in the lower valve near the hinge attaches the animal to the sea bottom, or to a rock or another shell as shown on page 10. Some persons have called brachiopods "lampshells" because the shape of the shells and arms reminds them of old Roman oil lamps and their wicks.

Brachiopods were numerous in ancient seas. Fossils of more than 6000 kinds have been found, although only about 200 kinds still live. Some living forms are almost identical with fossil brachiopods of nearly a half-billion years ago. It is puzzling to scientists how millions of generations of brachiopods could have lived and died and yet changed so little.

John's brachiopod as it might have looked when living

one knows what color most ancient sea animals were. Also, since the soft parts of most ancient animals disappeared soon after death, many details of their internal structure are unknown. So the pictures of ancient sea creatures (as well as dinosaurs!) are what scientists *think* the animals looked like. Reconstructing the life of an ancient sea animal on the basis of fossil evidence and the characteristics of similar living animals is a little like relying on circumstantial evidence in court.

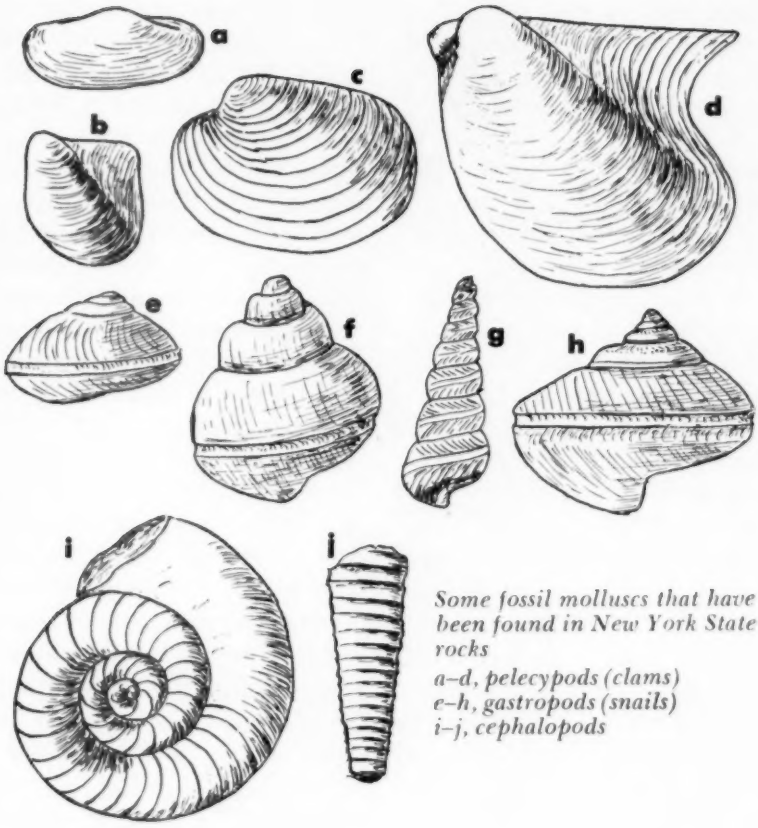
The classification of these ancient sea animals also is based on both their fossil structure and their similarity to groups of living animals. The shape of their shells or skeletons is known from fossils. Their habits and their internal structure are based largely on what we can observe of their living relatives.

***Brachiopods* (lamp-shells and similar animals)**

Among the most common fossil shells that you will find in New York State rocks are those of brachiopods (bra'ki-o-pods). These ancient types are extinct, but a few other brachiopods still live in the sea. However, the living animals are seldom seen, and few people know them.

Brachiopods are not closely related to clams and scallops, even though their shells look somewhat similar. If you examine a brachiopod shell closely, you will see that it is made of two halves, called *valves,* that differ slightly from each other. Unlike clams, whose valves cover their right and left sides, the valves of brachiopods cover the top and bottom of their bodies. When you hold your hands in front of you with your palms together, what arrangement of valves do you illustrate—that of a clam or of a brachiopod? How would you illustrate a brachiopod's valves?

A single valve of a brachiopod shell such as those shown on page 3, and on page 11, is symmetrical. This means that if you could cut a single valve down the middle, one half would just match the other. A clam valve, however, is not symmetrical. You cannot cut a single valve into two matching halves.



Some fossil molluscs that have been found in New York State rocks
a–d, pelecypods (clams)
e–h, gastropods (snails)
i–j, cephalopods

The fossil cephalopods that you may find in New York State rocks lived in chambered shells. Some were cone-shaped, some curved, and some coiled like that of the chambered nautilus. Their shells resemble those of gastropods except that cephalopod fossils often have lines to mark where the chambers are. The rocks that contain fossil cephalopods must have been formed from sea sediment, since cephalopods dwell only in the sea.

Corals

If you have seen the tiny freshwater animal called Hydra, you have some idea of what a single coral animal is like. With its many slender arms, called ten-

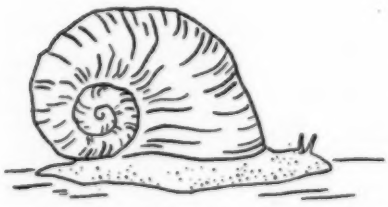
***Pelecypods* (clams and their kin)**

The fossil shells of these animals can be found in some rock layers, but they usually are not so common as those of the brachiopods. Occasionally, however, you may find a rock that contains a fairly large number of fossil pelecypods—evidence of an ancient clam bed in the sea. Today, living pelecypods vastly outnumber living brachiopods. Unlike brachiopods, however, some kinds of pelecypods live in fresh water.

The fossil shells of pelecypods differ from those of brachiopods in two ways:

1. A pelecypod valve is not symmetrical. You could not cut a single valve into two matching halves.
2. The valves of pelecypods cover the sides of the animal instead of the top and bottom.

The valves of pelecypods are mirror images of each other, even though each valve by itself is not symmetrical. The valves of pelecypods are hinged along the back, and this hinge is at the top in many living animals.



The snail is a gastropod whose shell oftens forms a fossil

***Gastropods* (snails, slugs and their kin)**

Snails of various kinds lived in the ancient seas, and their shells were commonly buried and preserved. None of the early kinds is still living, but many similar kinds thrive in the sea today. Some kinds abound in fresh water, and still others on land. Soft sea slugs may have lived in ancient seas along with shelled snails, but since slugs had no hard parts, they left no fossils. For the same reason, the slugs that you find in your garden today may not form fossils for future fossil finders.

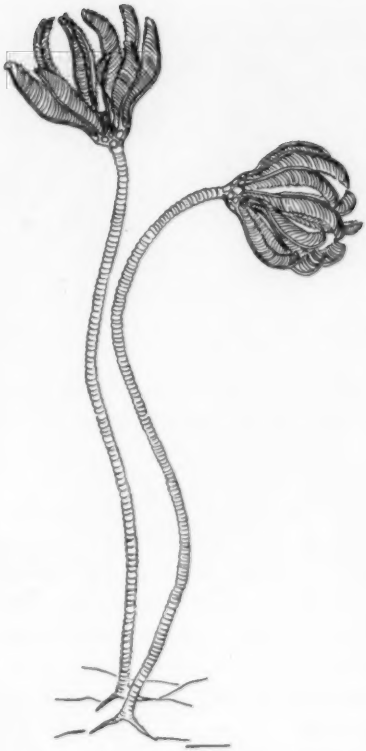
***Cephalopods* (squids, devilfishes, and their relatives)**

Cephalopods have soft bodies, tentacles surrounding their mouths, and many have well-developed eyes like our own. Unlike the snails which they often resembled, they were active creatures in ancient seas. Some were strong swimmers; others crawled along the sea bottom. Most had shells, although only a few of our living cephalopods still have shells. The rest are naked and have almost no skeleton.

***Crinoids* (sea lilies and feather stars)**

These creatures belong to the same group of animals as the starfishes, sea urchins and sand dollars—the echinoderms (e-ki'no-derms). Like other echinoderms, crinoids live only in the sea. For this reason, the presence of a fossil crinoid in a rock layer is good evidence that the rock was originally sea sediment. Crinoids were not only abundant in the ancient seas that once covered this region, but many forms still live in the sea.

Although they are animals, sea lilies, as their name implies, resemble flowers. They have long stalks, brilliant hues of lavender, red and yellow, and they grow in patches on the sea bottom. No wonder crinoids are called sea lilies! Perhaps you can picture their true animal character, however, if you imagine a starfish turned upside-down and attached to the sea bottom by a stalk.



The crinoid may look like a plant, but it is a stalked animal

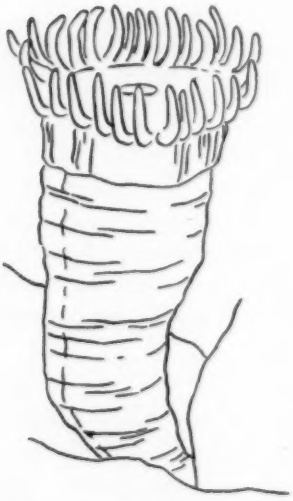
The honeycomb coral, Favosites, often formed large reefs

When crinoids died, they usually came apart very quickly. For this reason, complete fossil skeletons are rare. The parts most commonly found in rocks are pieces of the stalks, consisting of small button-like discs. Sometimes these have a tiny star in their center, or they are star-

tacles, often brightly colored, the living animals resemble tiny flowers in the sea. Corals have soft bodies—too soft to have been preserved as fossils—but around these soft parts they form a stony skeleton. Many corals lived in ancient seas and their skeletons are common fossils.

Some, built by single animals, resemble cow horns and are called "horn" corals. The animals that lived in these stony skeletons are known as *polyps*. They lived in the large end of the "horn", and gathered in food with the help of their slender tentacles.

Other coral skeletons were made by many small polyps living together in colonies. You might think of these huge colonies as coral apartment houses, each apartment occupied by a single polyp. The skeletons of some of these colonial corals resemble a honeycomb, and are popularly called "honeycomb" corals. Others have skeletons that consist of many round columns. Their resemblance to the pipes of an organ has given them the name "organ-pipe" corals. Still others, the branching corals, resemble branching plant stems or deer antlers.



The horn coral is a polyp with a stony skeleton

None of the kinds of fossil corals that you will find in New York State rocks are living today, but many similar kinds still live where the sea is warm and clear. There they form *coral reefs*—large masses of coral skeletons that have accumulated to form jagged beds of rock. Coral reefs form about a half million square miles of shallow ocean bottom. Think of the billions and billions of tiny animal skeletons it would take to make so much rock! The presence of extensive fossil coral reefs in New York State seems to indicate that long ago there must have been conditions similar to those where coral reefs are now found—warm, shallow seas.

Pieces of fossil crinoid stems

shaped, a hint of their relationship to the starfish.

Trilobites

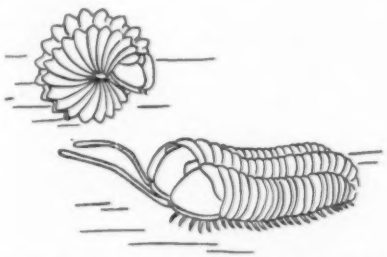
Not a single one of these animals is living anywhere in the seas of today. In fact, trilobites have been extinct for about 200 million years. Some scientists think, however, that crayfish, lobsters, crabs and other such crustaceans are living relatives of trilobites. The pill-bug that you can often find under wet boards or cardboard is an example of these "descendants" of the trilobite.

Fossils of trilobites are fairly common in New York State, although they are usually found only as pieces. A complete trilobite has a head section, often with two compound eyes similar to those of insects, a body part with many segments, and a more or less semi-circular tail. The fossil is probably the animal's skeleton.

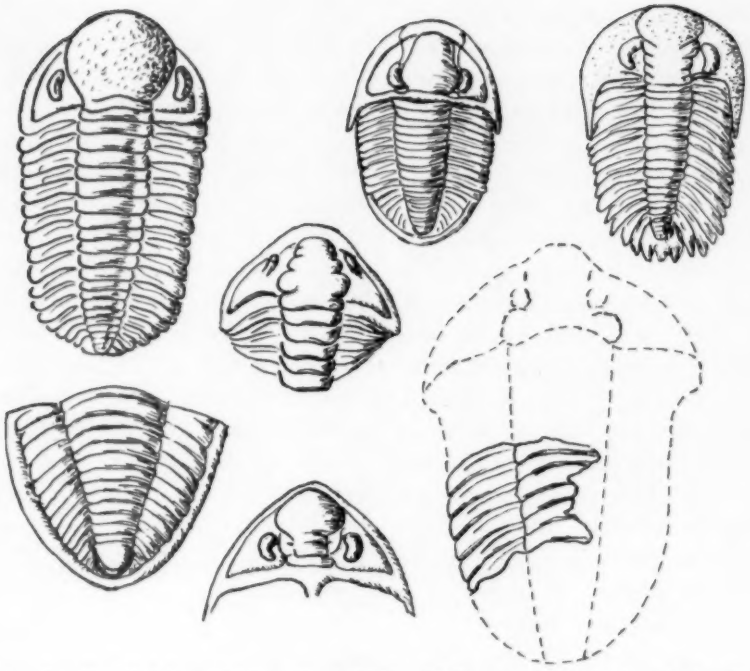
Like the crayfish or lobster, the skeleton of the trilobite was on the outside of its body. As you learned in *Beetles*, the Leaflet for Spring, 1957, such outer skeletons were shed occasionally as the animal grew. These cast-off outer skeletons became filled with sediment, were buried and preserved in the rocks. The inner, soft parts of the animal were rarely preserved. Trilobites had antennae and many legs, but fossils of these, too, are seldom found.

Trilobites have two distinct grooves down the back. These seem to divide the animal into three lengthwise sections or lobes. It is from these three lobes that the animal gets its name—tri-lobite.

As with many other ancient animals, trilobites are believed to have lived only in the seas. Thus the rocks in which they are found must have been formed from sea sediment.



Often trilobites rolled up for protection. You may find such a fossil



Some fossil trilobites of New York State. Often you will find only broken pieces and your imagination will have to supply the rest

***Bryozoans* (moss animals and similar forms)**

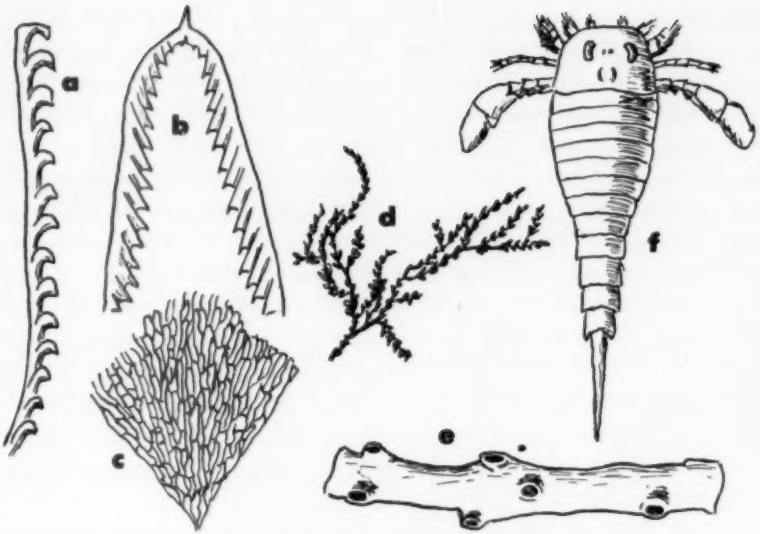
These small animals lived in colonies attached to shells, corals, seaweeds, or to the sea bottom. Their stony skeletons are of many shapes—some moss-like, some branching, some lacy, and some lumpy. All of them are covered with many tiny pores.

Many bryozoans still live in the seas, and a few live in fresh water. You may find some growing on the underside of stones in swift streams. These are living relatives of similar ancient bryozoans.

Other sea animals and plants

There were many other kinds of living things in the ancient seas. Sponges lived on the sea bottom, much as they do today—sometimes by the thousands. Starfish, and other relatives of the crinoids occasionally left skeletons, and some of their fossils have been found in our state.

When conditions were just right, many scorpion-like creatures called *eurypterids* lived in our seas. These animals, now extinct, sometimes grew to a length of nearly ten feet.



Some uncommon fossils from the rocks of New York State
a–c, graptolites (a, x5; b, x2) d, e, bryozoans (e, x10)
f, eurypterid (x ¼)

shore about 300 million years ago. These are the oldest known fossil forests anywhere in the world, and grew long before the more famous Petrified Forests of Arizona, or the Coal Age forests of Pennsylvania and other states.

Also in the Catskills, fossils of freshwater clams and fishes are found in ancient stream deposits. Probably there were still other kinds of creatures in fresh water and on land, including primitive insects, spiders and scorpions, but their fossils are rare in New York State because very few rock layers in the state are formed from land or freshwater deposits.

Fossils Are Evidence of Changing Land Forms and Climate

Fossil corals such as you read about on page 14 are common in many parts of New York State. Corals do not live on land or in freshwater lakes or streams. They live only in sea water. Moreover, they are found in far greater numbers in shallow, warm water than in deep, cold water. The abundance of fossil corals in New York State, then, indicates that when they were living, salty seas covered this region. It also indicates that these seas were probably warm and shallow.

Graptolites, an extinct group of coral-like animals, formed colonial skeletons that have left only dark lines like pencil tracings in the rocks. These fossils have been useful tools in identifying certain rock layers, however, as you will learn on page 20.

Swarms of microscopic creatures probably lived in the water, but they rarely left fossils. Seaweeds, too, were probably abundant, but they had no hard parts to be preserved. Worms, jellyfish, and many similar soft-bodied animals left only occasional impressions in the rocks. The countless plants and animals that had no hard parts have left little to tell us what they were like.

The Gilboa tree—a Devonian plant

The most highly developed animals were the fishes, but those that lived in ancient seas were much more primitive than the fish we catch now. Few, if any, of their fossilized skeletons are to be seen in New York State rocks, although in some other regions many fossil skeletons of ancient fish have been found. If in your search for fossils you find one that you think may be part of a fossil fish, be sure to consult some authority before you attempt to loosen it or you may spoil an otherwise valuable fossil.

Land and freshwater animals and plants

While ancient seas covered this region, plants and animals were also living on nearby land and in fresh water. Some of the best known are trees, which left coal-like material in some rock layers along with fossils of brachiopods and other sea animals. The trees were washed into the sea, became water-logged and sank. Silt covered them and they were preserved.

Near Gilboa in the Catskill Mountains, many fossil tree stumps have been found standing upright in the rock layers, indicating that this is where they once grew. The trees were fern-like, and lived in forests near the sea-

he carefully labels, describes, and puts away for future reference. Years later, another geologist studying the rocks of British Columbia finds several kinds of fossils, some of which he recognizes as nearly identical to those found in the "Cambrian" rocks of Wales. Since he finds these fossils in only some layers and no others, he can tell that these layers are of the same approximate age as the "Cambrian" rocks in Wales.

Still later, a third geologist studies the rocks near Little Falls, New York. He comes upon fossils very similar to those which were found earlier by the geologists in Wales and in British Columbia. He, too, searches the rocks above and below those in which he finds these fossils, but is unable to locate any except in certain layers. He concludes that these layers were formed about the same time as those in British Columbia and in Wales in which similar fossils were found. To all these rocks the geologists have given the name *Cambrian,* meaning that they were formed at about the same time as the rocks originally studied in Cambria (Wales).

There are many *systems* of rocks besides Cambrian. Some, called *Pre-Cambrian,* were formed by sea sediments even before the Cambrian rocks. The only fossils that can be found in these rocks, however, are a few of primitive algae and burrows of soft-bodied worm-like creatures. The real fossil record begins with the Cambrian and continues throughout all the younger rocks. With the help of these fossils the ancient history of a state, of a continent, or of the world can be read bit by bit as a fairly continuous story. For this reason, the beginning of the Cambrian period is an important time in geologic history.

Other Seas and Their Sediments

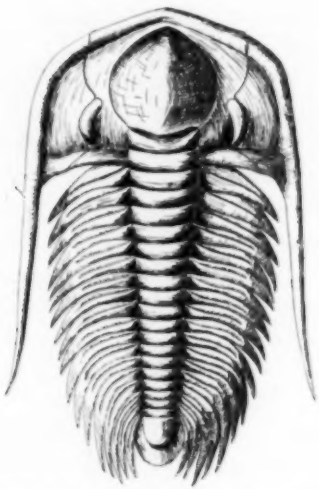
Just as Cambrian rocks are named after Wales, rock systems of other ages and other seas have been named for the regions where they are exposed and have been studied. *Mississipian* rocks, much more recent than Cambrian, were first studied in the Mississippi Valley. Still more recent *Jurassic* rocks are named for the Jura Mountains between France and Switzerland. The names of the rock systems visible in New York State, and the sources of their names are:

Pennsylvanian—the state of Pennsylvania

Mississippian—the Mississippi Valley

Devonian—Devon(shire), a county in southern England

In ancient times, seas covered much of what is now dry land. On the sea bottom lived many of the creatures whose fossils you have read about and will find in the rocks near your home. As these sea-bottoms were lifted, the water that covered them drained back into the ocean. What had been sea bottom became dry land. Still later, some of these land areas slowly settled, and the sea again moved over them. Each time the sea moved back and forth over the land, the sea creatures moved with it. Their preserved remains are our best clues to the advancing and retreating of these ancient seas, and the resulting changes in the coastlines.



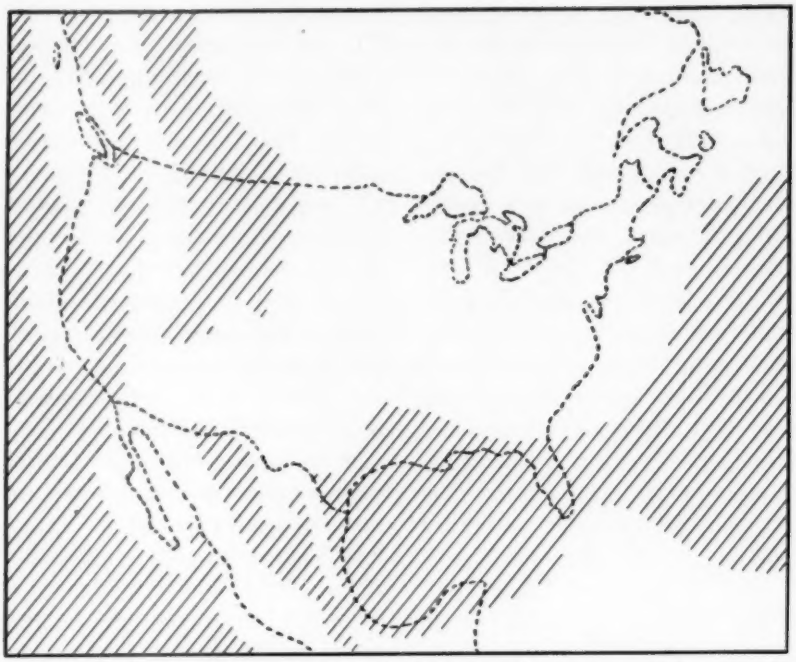
Paradoxides, an index fossil of the Middle Cambrian

Many sea sediments that were lifted above the sea were probably washed back into the ocean before they hardened. Thus the animal remains in them were not preserved. So our fossil record of the changes in ancient seas is not complete. Just as scientists have had to reconstruct some fossils on the basis of many bits, they have had to reconstruct the changes in ancient seas on the basis of the fossils they find, and the rocks in which they find them.

They Help Us Match Rock Layers

Some kinds of fossils are found only in certain layers of rock, and in no others. This means that these particular kinds of plants and animals lived for only a relatively short time in the history of the earth, then became extinct. Fossils that are restricted to certain layers can help us to identify those layers, not only in New York State, but also in Ohio, Pennsylvania, Canada, and wherever else they occur. Such *index fossils* help geologists to match up rocks of the same age in regions as far apart as New York and Sweden or Australia.

Imagine a geologist studying the rock layers in a country such as Wales (called *Cambria* by the Romans). In these "Cambrian" rocks he finds some fossils which



By Jurassic times much of the United States was above water. Where would you look for Jurassic fossils?

other insects abounded. Amphibians and occasional reptiles were to be found. At the same time, in the shallow seas that lay to the west, lived countless brachiopods, and molluscs (gastropods and pelecypods). These were different, however, from the older forms whose fossils are to be found in New York State.

As millions upon millions of years passed, more changes took place in the shape of the land. In the West, during the Jurassic, the seas retreated. They advanced again during the Cretaceous (named for the chalk cliffs of the English Channel), and for several million years a great sea extended across central western United States from Mexico to the Arctic Ocean. When the sediments of the Cretaceous seas were lifted, the Rocky Mountains were born. This marked the end of the vast seas that once covered our country.

While changes in land and sea were occurring in North America, there were equally great

Silurian—the Silures, an early people of Great Britain

Ordovician—the Ordovices, an early people of Wales

Cambrian—Cambria, the Roman name for Wales

It took millions of years for sediments to accumulate and form each of these rock systems. While Cambrian sea sediments were piling up, many changes were occurring in the level of the sea bottom and the surrounding land. Much of our state was dry land at the beginning of the Cambrian. However, by the end of the Cambrian (called *upper* Cambrian because it is represented by the upper layers of Cambrian rock), much of the eastern and southern parts of New York State were covered by a sea. Later, the land in this region was lifted slowly and the seas drained off. By middle Ordovician times, the state was again submerged and many forms of ancient sea life probably lived where you now live. The land was lifted and lowered repeatedly during ancient times. Each major shift left a corresponding fossil record in the rocks formed from sea sediments. By the end of the Devonian period (about 300 million years ago), most of our state was above the sea and has remained above sea level ever since. New York State fossils, then, are almost entirely those of Cambrian, Ordovician, Silurian and Devonian seas.

In Devonian times, the sea (shaded) covered most of southern New York State. Northern New York State was dry land

To the west of us, however, large shallow seas covered most of the Mississippi Valley for several million years after they had drained from our state. Here were formed extensive limestone rocks containing excellent fossil remains of plants and animals that lived during the Mississippian period.

During the Pennsylvanian period, while many of the western states were under sea water, there were extensive swamps in Pennsylvania and West Virginia. Here grew the great trees that later formed coal and oil deposits in those states. Dragonflies and

years of intense study and imagination to reconstruct the geologic changes that have occurred throughout the world. Sea sediments have continuously buried the remains of sea creatures. Although the process has never stopped, it has *not occurred continuously at any one place.* If it had, the sediments that would have accumulated since early Cambrian times would be about 100 miles thick!

By studying the fossil remains at various places, and by matching up the rock layers in widely separated regions, geologists have been able to determine the order in which the rock layers were formed. By putting together in one imaginary pile all of these layers, they have devised the *geologic time scale* shown on page 27. This will help you to see how the different periods of geologic time compare with each other, and what things lived during those periods.

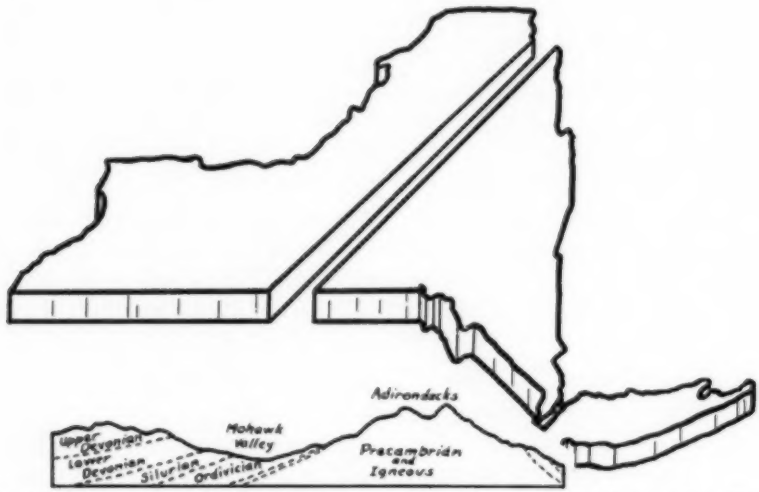
In places where seas did not cover the land after the Devonian period, there are no exposed rocks that are younger than Devonian. Where seas covered the land during the Jurassic, but not during the Cretaceous, there are no Cretaceous rocks on top of the Jurassic rocks. Also, whenever the sediments remained level as they were lifted above the sea, the uppermost and youngest rock layer hides the ones below it. Usually, however, the rock layers are not level, but are tilted or folded so that one layer will be exposed at one spot, and a different layer at another. In parts of New York State, for example, the rock layers have been tilted upward toward the north. This tilting amounts to as much as forty feet per mile. The diagram on page 24 shows how this tilting of the rock layers exposes the Silurian rocks at places several miles north of the Devonian exposures.

Running water also helps to expose rock layers that might otherwise be hidden by younger rocks. The gorges of New York State provide glimpses of small sections through the ancient rocks. In the Niagara River gorge, for example, Silurian rocks are exposed; in the Genesee River gorge—lower and middle Silurian; in Letchworth Park—upper Devonian rocks; and in the Helderbergs near Albany, there are more complicated formations of Ordovician, Silurian, and Devonian rocks. There are many less spectacular places in the state where you can see rock formations that represent ancient sea bottoms.

changes in other seas covering other lands. Shallow seas poured over much of Europe, then retreated, leaving fossil records in their rocks, too. In Australia, South America, and Asia the seas left their story in the rocks. Often, however, this story is incomplete.

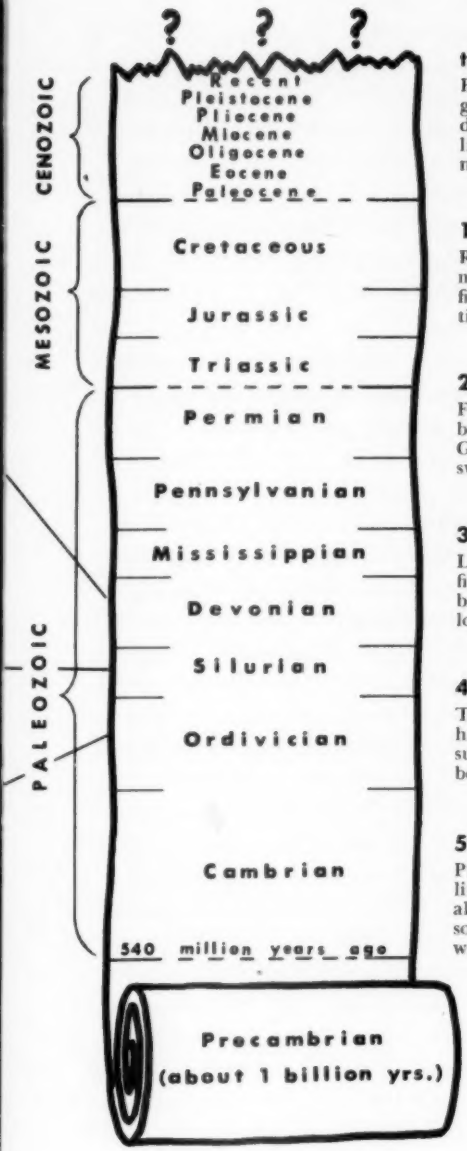
For example, during the middle Ordovician, seas covered great sections of New York State. Brachiopods and trilobites lived and died. Their remains were preserved in the sea sediments. By upper Ordovician times, many of these same sections were dry land. No longer were the remains of sea creatures being buried. In fact, the dry land was probably being eroded by rain and running water. Then, in lower and middle Silurian times the seas again covered much of the state, bringing with them sea creatures and sediments. Again a fossil record was made. But there was a gap of perhaps twenty or thirty million years when no fossils were formed in the dry sections of the state. While New York State was dry, Illinois to the west was covered by a sea. Here are found fossils that represent the gap in our own fossil record.

It has taken geologists many



An imaginary slice of New York State shows how the rock layers are tilted

GEOLOGIC TIME SCALE



today

Flowering plants increase to form forests and grasslands. Peak of herbivorous mammals. Mastodon, mammoth and horse rise and decline. Ape-like mammals appear. Man becomes the dominant species.

100 million years ago

Rise and decline of large reptiles (dinosaurs and marine reptiles). Bird-like reptiles give rise to first birds. Flowering plants appear. First primitive mammals appear.

200 million years ago

First reptiles appear. Reptiles and amphibians become widespread. Giant insects flit about. Great coal beds of the earth begin to form from swampy vegetation.

300 million years ago

Land plants become established. Early fishes (the first vertebrates) appear. A few fishes begin to breathe air, give rise to first amphibians. Cephalopods increase in numbers. Trilobites decline.

400 million years ago

The age of marine invertebrates. Trilobites inhabit the seas in vast numbers. Shelled animals such as brachiopods and molluscs numerous and becoming more so. Plant life primitive, marine.

500 million years ago

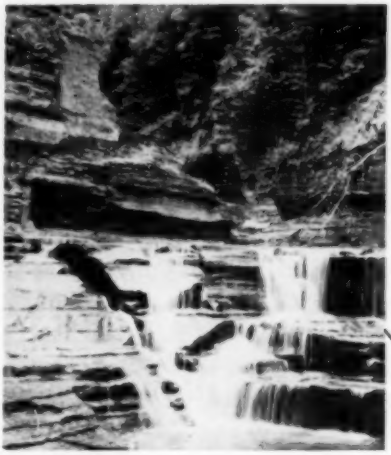
Precambrian rocks contain few fossils, indicating little life on the earth at this time. Animal life almost unknown. A few primitive plants leave some traces in the rock layers. This is the age of water, air, land and time—almost endless time!

Three Paleozoic Exposures in New York State

Top: Rock layers formed during the Upper Devonian are exposed in Enfield Glen, near Ithaca

Middle: The gorge below Niagara Falls exposes Middle and Lower Silurian rocks

Bottom: At Trenton Falls, north of Utica, the water flows over Middle Ordivician rocks. Here have been found some of the state's largest trilobites



the thousands of skeletons which they have produced.

Deep Freeze

In Siberia and Alaska, frozen ground sometimes yields the preserved carcasses of long-dead animals. Stories are told of wild dogs eating the flesh of these animals even though they have been dead for thousands of years. The cold temperature of the frozen ground has preserved them much as a freezer preserves your food. This is one of the few ways in which the soft parts as well as the hard parts of animals have been preserved.

There are a few other ways in which the soft parts of animals are preserved as fossils. Occasionally, under special conditions, soft-bodied animals such as jellyfish and worms were covered over quickly enough and protected long enough to leave an impression in the rock—an impression that has lasted for millions of years.

Are Fossils Always the Remains of Plants or Animals?

Most fossils that you will find are the preserved remains of plants or animals. Some fossils, however, are not. For example, the hard parts of some animals or

This dinosaur track was found in a slab of rock from the Connecticut Valley

plants that were buried in sediment until the sediment hardened. Then the hard parts slowly dissolved away, leaving a *mold* (cavity) in the rock. Such molds are the same size and shape as the hard parts that formed them. Minerals often seeped into these molds and were deposited. The resultant *casts* are perfect models of the animals that were buried.

Occasionally an animal such as a dinosaur left *tracks* in the mud. When conditions were just right, these tracks were preserved. Rocks containing dinosaur tracks have been found in many places near New York State.

Worm *burrows* are an additional bit of indirect evidence that soft-bodied creatures lived long ago. Sometimes these burrows became filled with sand.

Are Fossils Made Only in the Sea?

Burial in sea sediments is the most common way for fossils to be formed, but it is not the only way. Animals and plants that live on land may also become fossils, even though their soft parts usually are destroyed, and their hard parts scattered or crumbled into dust.

Volcanic Ash

In some places in the past there were volcanoes that erupted great quantities of dust and ash into the air. This ash settled on the surrounding countryside and often buried quickly things living nearby. In this volcanic ash many plants and animals have been preserved.

Amber

Have you ever seen sap oozing from various kinds of trees such as pine trees and cherry trees? In some places of the world, especially along the Baltic Sea, there were ancient pine trees that produced a sticky sap or resin. When these trees died, they became buried by sediment. Their wood was changed into a kind of coal. Their resin, however, hardened into a substance called *amber*. Perhaps you have seen amber beads or other jewelry. Just as an insect occasionally gets stuck in the sap of living trees, ancient insects and other small creatures got trapped in the sticky resin of ancient trees. The resin soon covered their bodies and preserved them. In time, the bodies of these insects dried and shrivelled, but the fossil resin still retained within it the impression of these creatures. Today we can examine the wings of an insect that died perhaps fifty million years ago.

Tar Pits

In a few places in the world, petroleum seeps from the ground. As part of the petroleum evaporates, a thick sticky tar is left on the ground. Animals living in regions where there are such tar seeps are constantly in danger of being trapped, especially at night when they do not notice the sticky tar. In California, tar seeps like these catch hundreds of animals such as ground squirrels, rabbits, snakes, insects, lizards and even birds. Slowly the tar flows over their bodies and protects the bones from destruction. This process has been going on for thousands of years. Scientists digging into dried tar deposits have uncovered the bones of hundreds of ancient animals such as horses, camels, giant ground sloths, and saber-toothed cats. The Rancho La Brea tar pits in California are world famous for

Not everything that resembles a fossil is one. These dendrites are only mineral deposits in the rock

dicate rapid erosion. Rapid erosion occurs when the land is steep and water runs swiftly over it. So an examination of the rock layers themselves also tells us about the geography of the past.

Are Fossils Being Made Now?

Today shallow seas cover what will someday be dry land. Hudson Bay, for example, is a shallow sea. It is not so warm as some ancient seas were, but its sediments probably cover many animal remains. Sometime the fossils that are formed from these remains will indicate what life was like 'way back in 1958.

The South China Sea is a vast, warm, shallow sea inhabited by large numbers of corals, clams, and many other hard-shelled creatures. One day—millions of years from now—this may be the site of fossil beds that contain records of our times.

As you journey about New York State and other places, look for signs of ancient seas and the life they contained. Start a collection of the fossils you find. If you learn to identify them, and keep records of where you found them, it won't be long until you can begin to read for yourself something of the record in the rocks.

When the rock containing these sand-filled burrows is weathered away, fossils resembling pencils are exposed.

Animal droppings are sometimes preserved. These are called *coprolites.* The bits of teeth, bones, scales and shells that the coprolites contain indicate the food eaten by the animal that dropped them. *Gastroliths,* or stomach-stones, were used by lizards in grinding their food, much as a chicken does. These rounded stones are sometimes found in the body cavities of fossil lizards.

All such fossils that are really not the remains of the animals themselves still help to interpret the record in the rocks.

Do Fossils Tell the Age of Rocks?

You have learned how fossils help geologists to recognize rocks of similar age in many widely scattered places in the world. Fossils indicate the relative age of the rock layers. That is, they help geologists determine whether one rock layer is older or younger than another. Fossils by themselves do *not* indicate the age of a rock in years. To do this, geologists must use other methods—methods that we might explain in some future number of the Leaflet.

Do Rocks Themselves Tell a Story?

Fossils are the best clues to conditions in ancient seas, but the rocks containing the fossils also give us some important clues. When the land near the sea is eroded, many of the rock particles are washed into the sea. Some particles are coarse and sandy. Others are of fine silt and clay. As long as the water flows swiftly, most of the particles are carried with it. When the water enters the sea, it slows and the particles begin to settle. The coarse, heavy particles settle first. Finer materials are carried farther out in the sea, where they settle slowly to the bottom. The resulting sea sediment is graded. Coarser material is nearer the shore; finer material is farther from shore.

Suppose a single rock layer formed from sea sediment is composed of coarse sandy material at one place, and finer, clay-like material some distance away. This would indicate the direction in which the shore line of the ancient sea lay.

The thickness of the rock layers is some indication of the steepness of nearby lands. A thick rock layer indicates a rapid accumulation of sediment. Large amounts of sediment usually in-

Additional Readings

Animals of Yesterday by Bertha Parker. Row, Peterson and Co., Evanston, Illinois. 1957. 36 pages. The emphasis in this booklet is on reptiles and mammals, but it includes a brief description of what fossils are and how they are formed. Intermediate.

The First Book of Prehistoric Animals by Alice Dickinson. Franklin Watts, Inc., New York. 1954. 92 pages. An illustrated account of the reptiles and mammals that have lived since the ancient seas receded from New York State. Intermediate.

Life Through the Ages by Bertha Parker. Row, Peterson and Co., Evanston, Illinois. 1956. 36 pages. The story of the changes in animal and plant life as recorded by the fossils in the rocks. Most of the booklet concerns life after the ancient seas no longer covered New York State. Intermediate.

Stories Read From the Rocks by Bertha Parker. Row, Peterson and Co., Evanston, Illinois. 1955. 36 pages. The story of a trilobite illustrates one method of reading the rock record. Minerals are helpful, along with fossils, in reconstructing the changes that have occurred in the earth's crust. Intermediate.

Life Long Ago by Carroll Lane Fenton. John Day Co., Inc., New York. 1937. 280 pages. This is a good, all-around introduction to ancient life that proceeds step by step through the fossil record. Invertebrate and vertebrate animals are given equal attention in both text and illustration. Intermediate, Upper.

Life Through The Ages by Charles R. Knight. Alfred A. Knopf, New York. 1946. 67 pages. A picture-story book about ancient reptiles and mammals. Each page of text faces a full-page illustration by the author, a well-known museum illustrator. Intermediate, Upper.

Handbook of Paleontology for Beginners and Amateurs, Part I, by Winifred Goldring. New York State Museum, Albany, New York. 1950. 367 pages. This handbook describes the fossils of New York State as well as the biology of similar living forms. Frequent reference is made to the location of fossil beds in New York State. Upper.

Prehistoric Animals by Sam and Beryl Epstein. Franklin Watts, Inc., New York. 1956. 192 pages. Following a short chapter on ancient sea life, the bulk of the book is devoted to vertebrate animals of ancient swamps and dry land. Upper.

Cooperative Extension Service, New York State College of Agriculture at Cornell University and the U. S. Department of Agriculture cooperating. In furtherance of Acts of Congress May 8, June 30, 1914. M. C. Bond, Director of Extension, Ithaca, New York.